

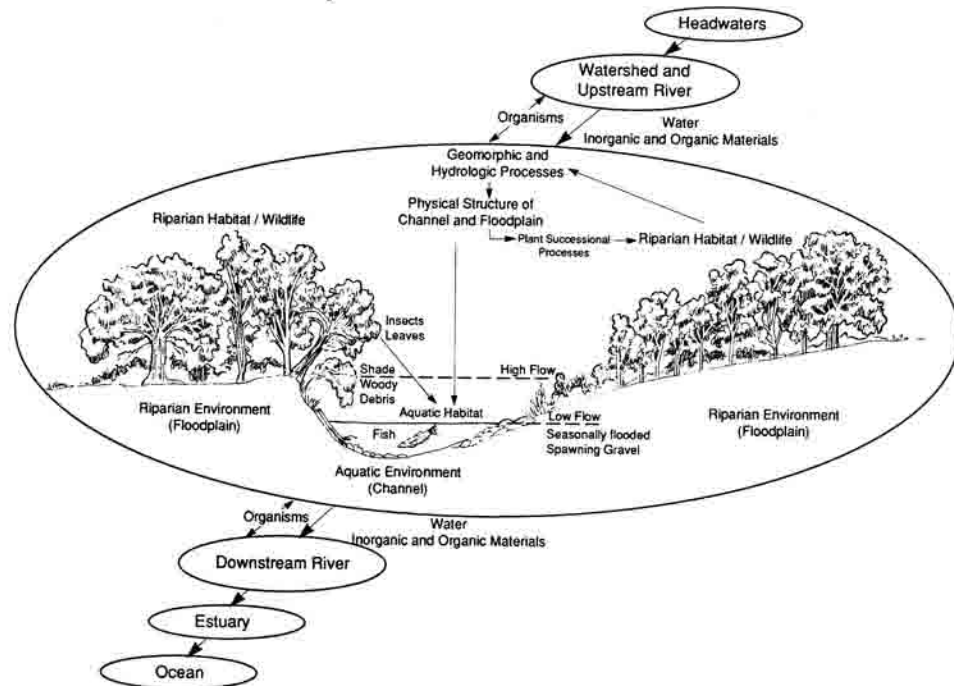
Rivers as Ecosystems—Systems of Interacting Environments and Organisms

To understand, sustain and manage natural systems it is useful to describe and categorize them as ecosystems, communities of organisms and their environments which are closely linked. A new national priority is emerging for the restoration and protection of rivers as ecosystems¹¹⁷.

A river ecosystem extends laterally over its entire flood plain and longitudinally from headwaters to the sea, lake or sink. The dynamism of rivers includes seasonal high and low flows, changes in channel and flood plain forms, and drought and flood events. Floods considered catastrophic to humans are not “disturbances” to river ecosystems. Most river biotic communities recover quickly from denudation or other mortality, and in fact large floods are beneficial for many species¹¹⁸.

Rivers are considered open ecosystems; a large proportion of organic matter and nutrients comes from outside the system, especially in headwater rivers. Once in the river system, materials are continually transported downstream in a one-way flow of water. The implications of this tendency to lose materials from a particular site along a river are several: 1) There must be a constant influx, either from terrestrial or upstream sources, of new material; 2) There needs to be certain amount of retention of materials at a site so that river organisms can take advantage of them; 3) Recolonization of disturbed aquatic habitats is generally from upstream; and 4) Materials tend to accumulate in downstream reaches.

Model of a River Ecosystem.



Relationship of River Geomorphology/Hydrology and Riparian Vegetation

No other aspect of California river ecosystems is so critical yet at the same time has been so ignored in river management as the interdependence of riparian habitat and river geomorphology and hydrology. The distinctiveness of riparian forests and woodlands and their high value for fish and wildlife habitat is largely due to the physical environments created by natural river processes.

Flood plain landforms present subtle but important variation in topography and soil texture. The height, shape and soil characteristics of river landforms combine with ground and surface waters to create unique plant environments. Species will predictably segregate in space over these different environments, and therefore riparian vegetation patterns can be used as indicators of hydrogeomorphic conditions¹¹⁹.

For alluvial, or meandering rivers, variation of river landforms over time is significant to riparian vegetation. As described previously, riparian vegetation successional processes must proceed in order to perpetuate the mosaic of riparian habitats. Without flooding, erosion and deposition, the large forests of riparian vegetation along valley rivers cannot be maintained naturally.

For constrained reaches, for example in narrow mountain valleys, riparian vegetation is less dependent in a positive way upon physical river processes, and must battle just to survive the frequently scoured environment.

The importance of riparian vegetation which has fallen into the active channel has only recently been explored. Sedell et al., (1988) in studying Pacific Northwest rivers found that woody debris increases the complexity of aquatic habitats by physically obstructing and diverting flow, which in turn creates backwater areas, pools and other depth variability. This debris also increases the retention of sediment and organic material, and is itself a place for organisms to colonize. During floods, logs can protect live vegetation, adding stability to a channel, or act as battering rams on banks and vegetation. After extreme large floods or landslides, channel equilibrium is restored faster with the stabilizing effects of woody debris. In rivers originating in heavily timbered and mountainous watersheds, it is not uncommon for such debris to come from upland as well as streamside forests.

Relationship of Riparian Habitat and Vertebrate Wildlife

Riparian vegetation is of extreme value as habitat for vertebrate wildlife species due to its: 1) predominance of woody plant communities (trees and shrubs); 2) presence of surface water and soil moisture; 3) diversity and interspersed of habitat features; and 4) function as corridors for wildlife dispersal and migration. Throughout the United States, riparian habitat has been shown to support a greater diversity and abundance of wildlife than practically any other cover type¹²⁰. Riparian habitats are characterized especially by a rich bird life.

For California, a major distinguishing feature of riparian vegetation is the dominance by deciduous species which create a virtual greenhouse environment¹²¹ in contrast with adjacent upland areas.

Riparian habitat in California is best developed along larger meandering rivers. Areas on higher flood plain terraces which grow into mature gallery forests represent the most productive habitat in the state. Such riparian forests have a highly complex structure, with a high tree-top canopy, many understory layers, often a thick ground layer, and a profusion of vines hanging in lianas from the uppermost forest strata to the ground. This dense and diverse vegetation provides a large variety and quantity of animal living requirements including: nesting and perching opportunities; food from seeds, fruits, and insects; and a shady, cool and moist microclimate. Riparian habitat supports many smaller birds, mammals, reptiles and amphibians which in turn are prey to larger vertebrates.

Relationship of Riparian Vegetation and Aquatic Community

Riparian vegetation has a major influence on aquatic communities in streams and rivers by physically altering the habitat, by affecting inputs of dissolved and particulate organic and inorganic

substances, and by providing terrestrial habitat for prey and predators of aquatic organisms. The close interrelationship of riparian vegetation and aquatic habitats has been reviewed by many, e.g. Baltz and Moyle (1984); Gregory et al. (1991); Knight and Bottorf (1984); and Meehan et al. (1977). Their description of ecosystem functions, both conceptual and quantified, are summarized below.

Riparian vegetation, through influences on channel and flood plain geomorphology, often plays a major role in shaping the structure of the underwater habitat. Submerged roots, branches and trunks usually enhance the productivity of a stream or river reach, particularly for fish.

Riparian vegetation can alter instream temperatures and reduce daily temperature fluctuations compared to an open stream by shading water from solar radiation. The temperature-moderating effects of riparian vegetation are strongest with smaller streams. On very large rivers, such as the Sacramento River, the effect of adjacent riparian habitat on overall water temperature becomes minimal.

Riparian vegetation is a major source of primary production for streams. In headwater areas, the input of plant material provides most of the base of the aquatic food chain. Coarse leaf and twig material is broken down in the stream by insects and microbes into fine and dissolved organic matter, some of which is consumed onsite, or is transported downstream.

Relationship of Rivers to Upland/Watershed

The influence of watershed condition on rivers and streams is readily observable when watersheds are artificially disturbed¹²². Logging, grazing and urbanization can significantly alter downstream waterways. Removal of vegetation, construction of roads, and alteration of drainage networks can lead to increased runoff and higher flood peaks, significant land erosion and reduced water retention for later release. Channels become unstable, with increased bank erosion, and riparian and aquatic habitats are destroyed or damaged, with almost no potential of easy recovery. Stream and river channels are subjected to flashier, sediment-laden flows during storms, and decreased base flows in the dry season.

Relationship of Rivers to Estuaries and the Ocean

Estuaries are enclosed bodies of water where fresh water from land meets salt water from the sea. Estuaries are among the most productive ecosystems in the world, supporting abundant shellfish, fish and bird life. Healthy estuarine ecosystems result in large part from the unique circulation patterns created by the mixing of salt and freshwater, and from large influxes of nutrients from streams and

ivers. River and stream flow amounts and timing are thus critical determinants of the character of estuaries.

The most severe problems in California estuaries include decreases in freshwater input or changes in flow timing, excess sedimentation and chemical pollutants.

An overview of California's estuaries can be found in the *California Comprehensive Offshore Resource Study (Draft)* by the State Lands Commission (1991). Reports on the status and trends of the San Francisco Bay / Delta Estuary, the largest estuarine ecosystem on the West Coast, include *The State of the Estuary* (1992), *Status and Trends Report on Aquatic Resources in the San Francisco Estuary* (1992), *Status and Trends on Wetlands and Related Habitats of the San Francisco Estuary* (1991), *Status and Trends Report on the Wildlife of the San Francisco Estuary* (1992), by the San Francisco Estuary Project; *Ecology of the Sacramento-San Joaquin Delta: A Community Profile*¹²³; and *Delta-Estuary: California's Inland Coast*, by the State Lands Commission (1991).

Materials transported by rivers also affect the ocean, the ultimate sink for most of California's natural waterways. As with estuarine systems, chemical pollutants from river runoff are a major problem for nearshore ocean environments.

Upstream-Downstream Variation

A river varies greatly over its length from headwaters to mouth. Environmental factors—flows, channel form, substrate texture, and temperature and other parameters of water quality—change longitudinally. The distribution of river organisms responds to these gradients in the environment, often resulting in recognizable zones. Aquatic species in particular have been studied world-wide to attempt to classify river reaches or zones¹²⁴. Moyle (1976) identified zones for California rivers and streams based on fish species distribution.

River Biodiversity

The California landscape, lying over a broad range of climates, soils and topography, yields an exceptional diversity of terrestrial, freshwater and estuarine plants, animals and natural communities, including species dependent upon river habitats. The ability to sustain these diverse and interdependent systems is threatened by human population growth, land and water development and the deterioration of water and air quality. Protection of biological diversity, or biodiversity, is the key to survival for all ecosystems.

Biodiversity is the variation in living resources at all levels of organization, including genes, species, communities and landscapes. Species diversity, which is all the different kinds of plants and animals in an area, is relatively easy to conceptualize. Equally important, although harder to study and understand, are the smaller and larger scales of

variation in the gene pools of populations or species, and variation in habitats and ecosystems over extensive landscape regions.

As examples of California's inherent biodiversity, Michael Barbour, a U.C. Davis botanist, wrote in *California's Changing Landscapes* . . . "of the world's ten major soils, California has all ten. As many as 375 distinctive natural communities have been recognized in the state." More than 5,000 kinds of native ferns, conifers and flowering plants have been identified. Japan which is similar in area to California has far fewer species, nor does Alaska match California's plant diversity." Moreover, about 30 percent of California's native plants are found nowhere else in the world."

Status of Biodiversity

The significant loss of natural diversity in California in the last 150 years is alarming. These losses are partly due to direct commercial exploitation of certain species, and partly due to the effects of human population growth and modern technology. In the last 200 years, numerous plants and animals have become extinct or have been eliminated from the state, including the thicktail chub, once one of the most common fishes of the Central Valley lowland rivers and Delta, and the grizzly, California's state mammal.

In California, freshwater-based natural systems are the most damaged of all ecosystems¹²⁵. The state's rivers have been distressed more than any other aquatic resource. No pristine rivers are left.

The biodiversity of California rivers is threatened by a battery of impacts: 1) vegetation clearing; 2) altered hydrology, sedimentation and erosion processes; 3) channelization; 4) watershed land use practices; 5) flood plain development; 6) pollution; 7) native species overharvest; and 8) exotic species introductions.

These impacts of human activity have either degraded or eliminated ecosystem parts—species populations and habitats, and interrupted natural ecosystem processes—flooding, erosion, and plant succession. Natural communities have become increasingly fragmented, with the result that species and habitats may no longer be self-sustaining within a region. This is especially true for riparian communities, which have been shrunk into narrow corridors and broken up along the lengths of river reaches.

Such fragmentation of riparian communities adversely affects river-dependent species and has major impacts on other species by destroying corridors between habitat areas.

Another significant threat to biodiversity is from the introduction of nonnative species. California's flora and fauna have been drastically altered over the last two centuries by the establishment of exotic plant and animal species. Although the ecology of invasion varies by individual species and environment, generally those ecosystem types which have suffered the greatest artificial

disturbance are the most susceptible to successful invasions of plants and animals¹²⁶. Rivers are among the most altered ecosystems in the state and most riparian and aquatic communities have been damaged by species introductions.

Trends in Protection of Biodiversity

Preserving areas in their natural states is the most effective way to maintain biological diversity¹²⁷. Numerous areas in California have been given official protection to preserve natural ecosystems, provide habitat for rare or endangered species, safeguard scenic areas, maintain open space or provide recreation in undeveloped areas. However, the protection of aquatic habitats in reserves has not been done on any significant scale.

The preservation of aquatic communities presents a difficult challenge. Activities on surrounding watersheds or in upstream reaches of water bodies have as much to do with the condition of a river, lake or estuary as uses onsite.

Restoration

Unfortunately, preservation of remaining natural areas is in itself not enough to ensure biological diversity because of the scarcity and fragmentation of relatively pristine systems. Species and community restoration of damaged ecosystems is also necessary for long-term protection of biodiversity, especially for aquatic ecosystems. The National Research Council (1992) has recommended that a national strategy for restoring rivers and other aquatic ecosystems be developed, with a target of restoring at least 400,000 miles of river ecosystems within the next 20 years.

With an understanding of natural processes, it is well to examine governmental processes to determine the status of the tools which already may exist for river restoration and those which yet may need to be developed.

CHAPTER FIVE

California Rivers: Restoration Tools And Beginnings

A Paul Bunyan saga tells how he floated many a log down the Round River. . . No one has suspected Paul of speaking in parables, yet in this instance he did. The [restless waters'] current is the stream of energy which flows out of the soil into plants, thence into animals, thence back into the soil in a never ending circuit of life.

*We of the genus Homo ride the logs that float down the Round River, and by a little judicious 'burling' we have learned to guide their direction and speed. This feat entitle us to the specific appellation sapiens. The technique of burling is called economics, the remembering of old routes is called history, the selection of new ones is called statesmanship, the conversation about oncoming riffles and rapids is called politics. Some of the crew aspire to burl not only their own logs, but the whole flotilla as well. This collective bargaining with nature is called national planning. Aldo Leopold, "The Round River," from *A Sand County Almanac*, 1949.*

There are a myriad of public and private organizations which have an interest in or some influence over the state's rivers or a particular waterway. The sheer number of such organizations is often overwhelming. Unfortunately, there is no one entity which, among other needed functions, synthesizes river and stream data, distributes it to interested parties, arbitrates disputes between competing legitimate demands for use of scarce river resources, and plans and coordinates watershed or bioregional level management of the use of riverbeds and their resources. On any given waterway, those resources may include aggregates, fish and wildlife and their habitats, consumptive use of water, recreation and aesthetics, flood control, hydroelectric power, water quality and many others.

Typically, one or more of these resource areas is served by a specific single-purpose governmental body devoted to the regulation and/or advocacy of the management of rivers and streams for that particular resource's needs. The net result of this narrowly focused and often uncoordinated regulatory and management activity is far too often the destruction of those natural values which made the river system valuable in the first place.

As a result, in California, as well as in other states, there is a growing movement toward cooperative watershed associations.

These watershed associations, often called watershed councils or alliances, may involve private landowners, government, resource users and citizen's groups. The point of such groups is to bring together all parties with a stake in restoring and managing a given watershed or waterway to find solutions to problems through consensus.

Mechanisms are needed which can harmonize competing uses where possible and to decide between uses when harmony is not possible if rivers, as viable, self sustaining systems, are to exist. The State, as public trustee, is a logical and essential focal point for the responsibility to initiate or coordinate such mechanisms.

It is neither necessary nor desirable to determine that one and only one use of a watershed shall dominate over all others. However, it is desirable that no one activity be allowed to destroy the very essence of the natural system, especially where the long-term costs to the public are unknown, and where the broader public has had little or no input into management decisions. The law of public trust suggests that legitimate needs for resources which only river systems can provide should take precedence over those needs which could be served by some other means. Where two uses are contemplated, one a trust use and the other a nontrust use, the nontrust use should be allowed only to the degree that it does not preclude trust needs.

The existence of governmental and nongovernmental involvement in decision-making and project implementation processes which affect rivers and streams illustrates just how diverse the various interested entities are, and, as a corollary, how complicated the task of coordinating those entities may be. It should be noted that the nongovernmental list in Appendix A is not intended to be comprehensive but rather a sampling of the extent and breadth of such organizations. The number of nongovernmental organizations suggests, however, that local interest in conserving and restoring rivers is increasing.

State Lands Commission Jurisdiction and Public Trust Responsibility

The State of California owns and administers several different types of interests in rivers and streams within the state's borders by virtue of being the sovereign representative of the people. These rights are the property of the state, and the state's powers with respect to these property rights are similar in certain ways to the rights of private property owners, but are governed by the law of public trust. These rights are grounded in English common law, as interpreted and applied by the federal and state court systems of the United States. The state is the guardian of those rights which fall under the protection of the ancient "Public Trust Doctrine," which in England governed certain rights and responsibilities which were

entrusted to the King. As a result, these rights collectively are often referred to as “sovereign” rights, or “sovereign lands.”

In California, sovereign rights and responsibilities of the state which are traditionally associated with real property ownership have been delegated to the State Lands Commission (SLC). The Public Trust Doctrine, as it affects these rights, is designed to protect the rights of the public to use watercourses for commerce, navigation, fisheries, recreation, open space, preservation of ecological units in their natural state, and similar uses for which those lands are uniquely suited.

Types of Jurisdiction and Interest

Public Trust - Sovereign Fee Ownership

The state owns, as trustee for the public, the beds of tidal navigable rivers and streams up to Ordinary High Water Mark (under natural conditions, that elevation reached by the average of all high tides over an 18.6 year period). The state similarly owns, in its sovereign capacity, the beds of all nontidal, navigable rivers and streams up to Ordinary Low Water Mark. (The term “ordinary” in each of the above statements is a legal term of art which refers to property boundaries, which may be sometimes, but not necessarily always, visible on the ground). Where the state owns the fee interest in the underlying land, its ownership has some of the same characteristics as private property ownership, but is subject to the constraints of the public trust doctrine. For example, the state can and does require compensation to the public for any private use of its property, including both surface use and the extraction of resources from the land. However, the state does not have the unfettered right to alienate its trust property.

Public Trust - Easement

Along navigable nontidal waterways, the state also owns a right often termed the “public trust easement” in the area between Ordinary Low Water Mark and Ordinary High Water Mark. The state has both the right and the obligation to balance competing land uses in the easement area. In general, the title of a private owner of the fee underlying the state’s easement is subservient to the easement, although the fee owner may use the lands in any way “not inconsistent with public trust needs.”

Navigation Rights

In California, members of the public have a right to utilize for boating, fishing and similar water dependent uses any waterway that

is susceptible of being navigated by even the smallest recreational craft, where access to the waterway may be legally obtained. Under well-established California law, this right to utilize such waterways exists even where the bed is privately owned. Any member of the public, or the state acting on behalf of the public, may enjoin any interference with this right.

Right to Abate Nuisance

The state has a right (and, under trust law, an obligation) to seek to abate any nuisance activity, whether on public or private property, which can be demonstrated to have a deleterious effect upon the property, or the rights associated with the property, which is subject to the Public Trust Doctrine. Obstructions to navigation and the pollution of waterways are examples of types of nuisances that can be abated.

Access

The Act for the Admission of California to the Union and the State Constitution provide that protection of the public's right to use navigable waters is a paramount responsibility of state government. In addition, several statutory provisions exist (most notably, the Subdivision Map Act) which require that public access to and along waterways be provided. The public does not, however, have a right to cross private property to access public waterways unless there is a legally protected express or implied right to do so.

Legal Bases for Jurisdiction and Interest

Act for the Admission of California to the Union

Section 3 of the Admission Act provides, in part:

... that all the navigable waters within the said State shall be common highways, and forever free, as well to the inhabitants of said State as to the citizens of the United States, without any tax, impost, or duty therefor.

California Constitution

The California Constitution, Article 10, Section 1, states:

The right of eminent domain is hereby declared to exist in the State to all frontages on the navigable waters of this State.

Article 10, Section 4, provides:

No individual, partnership, or corporation, claiming or possessing the frontage or tidal lands of a harbor, bay, inlet, estuary, or other navigable water in this State, shall be permitted to exclude the right of way to such water whenever it is required for any public purpose, nor to destroy or obstruct the free navigation of such water; and the Legislature shall enact such laws as will give the most liberal construction to this provision, so that access to the navigable waters of this State shall always be attainable for the people thereof.

California Statutes

Division 6 (Public Lands) of the Public Resources Code (PRC), beginning with Section 6001, spells out the varied powers and responsibilities of the State Lands Commission, including those relating to management of rivers and streams. Some of the more important sections of the PRC are cited below.

PRC Section 6301 provides, in part:

The commission has exclusive jurisdiction over all ungranted tidelands and submerged lands owned by the State, and of the beds of navigable rivers, streams, lakes, bays, estuaries, inlets, and straits, including tidelands and submerged lands or any interest therein, whether within or beyond the boundaries of the State as established by law, which have been or may be acquired by the State (a) by quitclaim, cession, grant, contract, or otherwise from the United States or any agency thereof, or (b) by any other means. All jurisdiction and authority remaining in the State as to tidelands and submerged lands as to which grants have been or may be made is vested in the commission.

PRC Section 6307 authorizes the commission, under limited circumstances, and upon making appropriate findings, to exchange lands, where to do so would result in a net benefit to the public trust.

PRC Section 6357 authorizes the commission to "... establish the ordinary high-water mark or the ordinary low-water mark of any ... tide, or submerged lands of this State, by agreement, arbitration, or action to quiet title, whenever it is deemed expedient or necessary."

Case Law

There are literally dozens of cases which deal with state jurisdiction over rivers and streams. There are also several appellate decisions, many of which involved the State Lands Commission as a party, which explain the specifics of California's jurisdiction. Some of the more important decisions are listed in Appendix A.

Two important lines of cases have helped to define and refine the role of the state as public trustee for rivers and streams. One series of cases defines the scope of the trust and the duties of the trustee, while the other spells out the geographic extent and the navigation rights associated with that authority and responsibility.

In the first instance, the courts have held that the state, as trustee, is bound by a very stringent standard of conduct in its stewardship of trust resources. A recent example of this principle is the California Supreme Court's language in the *National Audubon* (33 Cal.3d 419 (1983)) decision which states that the state has "an affirmative duty to take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible." That language is the most clear statement to date that the state is not free to decide when and where it will apply the principles of the Public Trust Doctrine, but must actively seek to protect those properties and values which form the corpus of the trust. On the other hand, the state does have a great deal of discretion to balance, and to choose between, conflicting uses which are themselves consistent with the principles of the doctrine. For example, the state may authorize construction of a port facility even though an effect of that construction may be to prevent fishing within the port boundaries (of course, separate environmental legislation such as CEQA places additional constraints upon state action).

The Public Trust Doctrine seems to be at least as much a limitation on the powers of government as it is specific direction to act. It is clear from a reading of cases beginning with *Illinois Central* (146 U.S. 387 (1892)) and extending through *Audubon* (supra) that the Public Trust Doctrine will be invoked by the courts to tell a state government when and where it has gone too far in ignoring its trust responsibilities.

The cases which describe the geographic limits of trust jurisdiction and the public rights that go with the public trust have also been reaffirmed over time, as increasing pressure on river resources has created conflict between prospective users, and between natural systems and users. When population distributions were largely sparse and rural, and travel was more difficult, there was not much competition for use of river resources (with the exception of the water itself). There were seldom conflicts over access or over potential destruction of natural systems, and therefore no need for detailed analyses of jurisdictional limits. However, as population density and

urban development increased, and people became more sophisticated and aware of the degradation of their natural surroundings and the impacts of that degradation on the quality of life, increasing and more strident conflict arose. As a consequence, disputes over ownership and jurisdiction over rivers became more frequent. The courts are today being asked to resolve conflicts between citizens who want access to and along streams which may have been used by members of the public for generations, but which are now closed off by owners of upland property.

The courts have, as a general rule and in keeping with the spirit of the Public Trust Doctrine, always been protective of the public's right to access to waterways. Courts have carefully examined the elements of navigability which determine state ownership of title to the bed of a river, taking notice of surrounding circumstances and expectations. A careful reading of the decisions leads to the conclusion that the decisions have become increasingly detailed, in order to provide guidance to both public and private parties. The newer decisions provide extensive detail about what constitutes the sort of "commerce" that would support state ownership, or about what circumstances would indicate that a waterway was susceptible of supporting commercial navigation.

A listing of federal and state agencies with management or regulatory functions or responsibilities affecting California's rivers is set forth in Appendix A of this summary.

Endnotes

1. Kroeber, 1925.
2. Kroeber, 1935.
3. Kroeber, 1925; McEvoy, 1986.
4. Tripp, 1984.
5. Kroeber, 1925.
6. Lufkin, 1991.
7. Yeend, 1974.
8. Kroeber, 1925; Roberts, 1932.
9. Kroeber, 1925.
10. Schulz and Simons, 1973.
11. Kroeber, 1925.
12. McEvoy, 1986.
13. Reynolds et al., 1990.
14. McEvoy, 1986.
15. McEvoy, 1986.
16. Lufkin, 1991.
17. McEvoy, 1986.
18. Thompson, 1961.
19. Downie, 1991.
20. Dasman, 1965.
21. Beck and Haase, 1974.
22. California Water Atlas, 1979.
23. DWR, 1992a.
24. DWR 1992b.
25. DPR, 1984.
26. Loomis, 1989.
27. Sport Fishing Institute, 1989.
28. DFG, 1991b.
29. DFG, 1991a.
30. DFG, 1991a.
31. NPS, 1990.
32. Charbonneau and Kondolf, 1991.
33. SWRCB, 1991a.
34. SWRCB, 1991a.
35. Rick Humphries, SWRCB, pers. comm. 4/1993.
36. CDF, FRRAP, 1988.

37. Reid and Dunne, 1978.
38. Everest et al., 1987; Newcombe and MacDonald, 1991.
39. Beschta et al., 1987.
40. Armour et al., 1991, Chaney et al., 1990.
41. Elmore, 1989.
42. California Advisory Committee on Salmon and Steelhead Trout, 1988.
43. National Research Council, 1992.
44. Upper Sacramento River Fisheries and Riparian Habitat Advisory Council, 1989.
45. Kondolf and Swanson, 1993.
46. Kondolf and Matthews, 1990.
47. Department of Food and Agriculture, 1992.
48. Baily, 1993.
49. SWRCB, 1990.
50. SWRCB, 1991.
51. SWRCB, 1990c.
52. SLC, 1986.
53. Holland and Faber, 1988.
54. National Research Council, 1992.
55. Jenkins, 1938.
56. Moyle, 1976.
57. Roberts, et al., 1977.
58. SLC GIS analysis based on 1:1,000,000 USGS Hydrography map.
59. Ray et al., 1984.
60. California Advisory Committee on Salmon and Steelhead Trout, 1988.
61. Moyle et al., 1989.
62. Katibah, 1984.
63. DFG, 1991a.
64. Reynolds et al., 1990.
65. California Advisory Committee on Salmon and Steelhead Trout, 1988.
66. Reynolds et al., 1990.
67. Reynolds et al., 1990.
68. Upper Sacramento River Fisheries and Riparian Habitat Advisory Council, 1989.
69. Hedgpeth, 1991; Higgins, 1991.
70. Minshall et al., 1989.
71. Nehlsen et al., 1991.
72. Ohmart et al., 1977.
73. Minckley and Brown, 1982.
74. Moyle, 1976.
75. Laymon and Halterman, 1989.
76. DFG, 1992.
77. Keller, 1977.
78. Jensen and Platts, 1989.

79. Cowardin et al., 1979; National Research Council, 1992.
80. Gregory et al., 1991.
81. Gregory et al., 1991.
82. Kelsey et al., 1981.
83. Scott and Marquiss, 1984; Thompson, 1961.
84. Scott and Marquiss, 1984; Thompson, 1961.
85. National Research Council, 1992.
86. Reid and Wood, 1976.
87. Hynes, 1970.
88. Cummins, 1974.
89. Fjerdingstad, 1975.
90. Goldman and Horne, 1983.
91. Goldman and Horne, 1983.
92. Cummins, 1974.
93. Goldman and Horne, 1983.
94. Goldman and Horne, 1983.
95. Eng, 1984.
96. Moyle, et al., 1989.
97. Moyle and Leidy, 1992.
98. Moyle and Williams, 1990.
99. Moyle, 1986.
100. McGinnis, 1984.
101. Moyle, 1986.
102. Smith and Stearly, 1989.
103. Fry, 1979.
104. Moyle, 1976.
105. Trotter, 1989.
106. DFG, 1991c.
107. Nehlsen et al., 1991.
108. PFMC, 1992.
109. Reynolds et al., 1990.
110. PFMC, 1992.
111. Miller, 1951.
112. Trapp et al., 1984.
113. Faber et al., 1989.
114. Mayer and Laudenslayer, 1988.
115. Brinson et al., 1981; Stone, 1976b.
116. From information in Brode and Bury, 1984; and Zeiner et al., 1988, 1990a & b.
117. National Research Council, 1992.
118. National Research Council, 1992.
119. Hupp and Osterkamp, 1985.
120. Brinson et al., 1981.
121. Roberts et al., 1977.
122. Debano and Schmidt, 1989.
123. Herbold and Moyle, 1989.
124. See Hawkes, 1975; Hynes, 1970.

125. Jensen et al., 1990; Mooney et al., 1986.
126. Mooney et al., 1986.
127. U.S. Congress, Office of Technology Assessment, 1987.

Appendix A

The matrices following the listing below characterize the functions or responsibilities of the federal and State agencies listed.

The Federal Role

Department of Agriculture

United States Forest Service (USFS)
U.S. Soil Conservation Service (SCS)

Department of Commerce

National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)

Department of Defense

United States Army Corps of Engineers (COE)

Department of Energy

Federal Energy Regulatory Commission (FERC)

Department of the Interior

Bureau of Land Management (BLM)
Bureau of Reclamation (USBR)
U.S. Geologic Survey (USGS)
U.S. Fish and Wildlife Service (USFWS)
National Park Service (NPS)

Department of Transportation

U.S. Coast Guard

Other Federal Agencies

Environmental Protection Agency (EPA) (Independent Agency)

Federal Emergency Management Agency (FEMA)

The State Role

Business and Transportation Agency

Department of Transportation (CALTRANS)

Environmental Protection Agency (Cal-EPA)

State Water Resources Control Board (SWRCB)

Regional Water Quality Control Boards (RWQCB)

Department of Toxic Substances Control (DTSC)

Department of Pesticide Regulation (CDPR)

Resources Agency

San Francisco Bay Conservation and Development Commission (BCDC)

California Coastal Commission (CCC)

Delta Protection Commission (DPC)

Boating and Waterways (B&W)

Department of Conservation (DOC)

Department of Fish and Game (DFG)

Wildlife Conservation Board (WCB)

Department of Parks and Recreation (DPR)

Department of Water Resources (DWR)

State Reclamation Board (Rec. Board)

Energy Commission (EC)

California Department of Forestry and Fire Protection (CDF)

State Conservancies

Several conservancies which have river-related obligations operate under the aegis of the Resources Agency. These agencies facilitate public and private initiatives to preserve, rehabilitate and protect natural systems, through programs of land acquisition and grants. The Coastal Conservancy, the Tahoe Conservancy, the Santa Monica Conservancy and the newly created San Joaquin River Conservancy are examples.

Governor's Office

State Historic Preservation Office (SHPO)

Federal Entities Affecting California Rivers—Resources and Uses.

MANAGEMENT/REGULATORY FUNCTION	USFS	USSCS	NOAA	NMFS	COE	FERC	BLM	USBR	USGS	USFWS	NPS	USCG	EPA	FEMA
Forest Management/Logging	+													
Grazing	+						+							
Wildlife Management/Protection (All Unless Noted)														
Habitat Management/Riparian	+						+			+				
Endangered Species				+						+				
Species of Concern														
Recreation (All Unless Noted)	+						+							
Fishing														
Boating														
Camping														
Technical Assistance (All Unless Noted)		+	+											
Resource Planning										+				
Restoration										+				
Soil														
Water									+					
Resource Information									+	+				
Estuarine Management/Restoration			+							+			+	
Coastal Resources			+							+				
Commercial Fishing				+										
Navigation Improvements					+									
Dredging					+									
Flood Control (All Unless Noted)					+									
Levee Maintenance														
Wetlands					+		+			+				
Shore Protection					+									
Structures/Waterway					+									
Mining/Reclamation														
Water Development (All Unless Noted)								+						

Federal Entities Affecting California Rivers—Resources and Uses.

[illegible]

State Entities Affecting California Rivers—Resources and Uses.

MANAGEMENT/REGULATORY FUNCTION	SLC	CT	SWRCB	DTSC	CDPR	BCDC	CCC	DPC	DPR	DWR	B&W	DFG	DOC	SRB	CDF	SHPO	EC
Public Trust-Sovereign Fee Ownership	+														+		
Forest Management/Logging	+																
Grazing	+																
Wildlife Management/Protection (All Unless Noted)												+					
Habitat Management/Riparian	+																
Endangered Species																	
Species of Concern																	
Recreation (All Unless Noted)									+								
Fishing	+																
Boating	+										+						
Camping																	
Technical Assistance (All Unless Noted)																	
Resource Planning												+					
Restoration												+					
Soil																	
Water																	
Resource Information												+					
Estuarine Management/Restoration						+	+										
Coastal Resources	+					+	+										
Commercial Fishing												+					
Navigation Improvements																	
Dredging	+					+											
Flood Control (All Unless Noted)														+			
Levee Maintenance																	
Wetlands	+					+											
Shore Protection	+																
Structures/Waterway	+																
Mining/Reclamation	+												+				

State Entities Affecting California Rivers—Resources and Uses.

[illegible]

The Local Role

Local Government

Decisions by local governments, in particular, may have a profound impact on the health of river systems which pass through city or county jurisdiction. In addition to their normal planning responsibilities, local governments are delegated lead agency responsibility for ensuring that aggregate producers comply with the Surface Mining and Reclamation Act (SMARA) (Public Resources Code Section 2710, et seq.) That responsibility includes the permitting process itself, and follow up on approved reclamation plans. Since instream and/or near-stream aggregate mining can have such significant impacts on the character of both upstream and downstream reaches of a stream system (see Chapters 1 and 3) the local role may be pivotal for the continued well-being of the system as a whole. Local government bodies which play a particular role in the SMARA process may include city and county planning commissions and elected governing boards or councils.

Other local government bodies which play a role in stream management include flood control districts, parks departments, water districts, community service districts, resource conservation districts and, in some cases, special districts or commissions set up specifically for stream management. The City of Redding, for example, has a Sacramento River Commission which advises the city on river corridor management issues.

Local Jurisdictional Planning Authority

Local governments (Counties and Cities) are required (Government Code, Section 65000 et seq.) to have a general plan with mandated elements including open space/conservation, safety, land use and circulation. There are very few regional requirements for plan consistency between the counties and cities.

The general plan land use element delineates the general distribution, location and extent of local development patterns and land use.

The conservation element addresses the "conservation, development, and utilization of natural resources, including water and its hydraulic force, forests, soils, rivers, and other waters, harbors, fisheries, wildlife, minerals, and other natural resources."

The open-space element defines provisions for open space for the preservation of natural resources, the managed production of resources, outdoor recreation, and public health and safety.

Zoning Ordinances

State law requires that the adopted zoning ordinance and map must be consistent with the general plan. In general, there has not been a mechanism to assure consistency between or among general plans at the regional level. For example, until the enactment of the Delta Protection Act (Public Resources Code Section 29700 et seq.), there were no comprehensive local governmental zoning tools in the Delta area that could be applied effectively against the alteration of significant resource areas.

Subdivision Ordinance Controls

The Subdivision Map Act (§64478 et seq.) requires that a subdivision map be reviewed and approved by the appropriate local government for all projects creating five or more parcels of land or condominiums. Maps may be denied if a finding is made that the subdivision and proposed improvements are likely to cause substantial environmental damage. In general, local governments must incorporate adequate criteria or habitat descriptions into their subdivision ordinances to implement the state law. The Subdivision Map Act (Section 66478.1) requires that reasonable public access to rivers be provided as part of the subdivision process.

Local Agency Formation Commission (LAFCO)

LAFCOs coordinate and approve changes in local government boundaries by authority of the Knox-Cortese Act; LAFCOs have authority over all cities and special districts requesting changes in geographic or public service boundaries; and establish “spheres of influence” for cities and districts. Government Code section 56108 provides that no tidelands or submerged lands which are owned by the state or by its grantees may be incorporated into, or annexed to, a city without the approval of the State Lands Commission.

Special Districts

Resource Conservation Districts are authorized by Division 9 of California Public Resources Code to assist the state in conserving soil and water resources on farm, range, urban and timber lands. The districts provide assistance to landowners and government agencies to prevent soil erosion, control runoff, stabilize soils and protect water quality. Districts receive technical assistance from the USDA Soil Conservation Service. Each district prepares a long-range plan for lands within its boundaries.

Open Space and Park Districts acquire and preserve open space lands, and manage wildlife, recreation and stock animals.

Reclamation Districts were the first special districts established by law. There are 108 reclamation districts which are responsible for levee maintenance. These special districts are formed and supported by the landowners of the area protected by the levees. Except for maintenance of Corps project and direct agreement levees, they are subject to limited state and federal flood maintenance and environmental requirements and virtually no local planning regulations. However, in many cases, Reclamation District projects are subject to the jurisdiction of the State Lands Commission. When state subsidy funds are used, or if construction activities on private levees require a permit from the Corps of Engineers or the State Lands Commission, environmental conditions can be imposed.

Utilities

Public utilities have developed both domestic water supply and power generation facilities on most major California watersheds. Pipelines are also often operated by utilities. Insofar as river management is affected, it probably makes little difference whether the utility in question is public or privately owned and operated. Because privately held utilities are regulated by the Public Utilities Commission, they tend collectively to act somewhat like quasi-public agencies.

In Southern California, the activities of the giant Los Angeles Department of Water and Power (DWP) in the Mono Lake area and in the Owens Valley are well documented. Other major utilities with active operations in the area include Southern California Edison, the San Diego Gas and Electric Company, and the Metropolitan Water District (MWD) of Southern California.

In Northern California, the collective impact of utility operations on rivers and streams is even more far-reaching. The Sacramento Municipal Utility District (SMUD) has constructed and operates several dams and associated power generation facilities on the American River system. The East Bay Municipal Utilities District (EBMUD) operates facilities on the Mokelumne River watershed and also has access to American River water above Sacramento. The City and County of San Francisco divert Tuolumne River water at Hetch Hetchy Reservoir near Yosemite. For sheer numbers of facilities, the Pacific Gas and Electric Company (PG&E) is the unquestioned leader. PG&E operates 19 power plants on the Feather and the Pit/McCloud river systems, for example.

Irrigation Districts

Local and regional irrigation districts (often called simply "water districts") construct, operate and maintain diversion and drainage works to support agricultural use of water. Typically, such districts buy water from a wholesaler such as the CVP or the SWP,

but some districts also possess riparian rights to divert significant quantities of water. In either case, the diversions themselves are subject to the permitting requirements of the SWRCB. Since agriculture is the single largest user of water resources in California, the operating procedures and facilities utilized to supply that water can be expected to, and do, dramatically affect the quality of instream and riparian resources. Fisheries, in particular, are sensitive to agricultural diversion practices. Drainage of runoff water from agricultural use may also play a significant role in fisheries and wildlife management within river systems.

Sanitation Districts

Local and regional sanitation districts treat and dispose of industrial and domestic sewage, most often by discharge into local rivers and streams. Many districts are now capable of tertiary treatment, although many others are only capable of secondary treatment.

Flood Control Districts

Flood control districts are responsible for developing facilities for the conveyance, containment, storage and distribution of flood flows, so that domestic and agricultural lands are not unnecessarily flooded. Flood management facilities may consist of modified natural channels, lined channels, dams, catch basins, diversion and energy dissipation structures, bypass, detention and storage facilities, and similar engineered flood responses. Degradation of aquatic and riparian habitats typically results when natural channels are managed primarily for flood control. The presence of flood control structures often regulates water flows to the detriment of downstream channels.

The Private Role

Private Organizations

American River Coalition

The American River Coalition came together in 1989 as a group of 27 different recreation, business and environmental organizations all dedicated to preserving the American River. Coalition efforts center around attaining river protection designations such as federal Wild and Scenic and National Recreation Area status, as well as full-time efforts to prevent the Auburn Dam and help resolve flood control issues for the Sacramento area. The coalition is a Friends of the River-funded project.

California Salmon, Steelhead and Trout Restoration Federation (CSSTRF)

The CSSTRF holds an annual California salmon, steelhead, and trout conference in different areas of the state with significant salmonid fisheries. Conferences typically focus on restoration problems of special concern in the area where the conference is held, such as gravel extraction and timber harvest for the north coast. The federation also provides educational, referral, and liaison services to the organizations, businesses and individuals actively engaged in restoring the state's salmonid populations. Beginning in the summer of 1993, the federation will be operating a fish restoration technical school in Quincy (Plumas County) that is open to the public.

California Trout, Inc. (CalTrout)

Since its formation in the 1960s, CalTrout has worked to preserve, protect and restore wild trout, native steelhead and their waters in California. CalTrout led the efforts in 1969 to block the proposed construction of Dos Rios Dam on the Middle Fork of the Eel River. CalTrout also played a major role in the passage of the California Wild and Scenic Rivers Act of 1972, and was instrumental in getting the North Coast Rivers (and the American River) enrolled on the federal Wild and Scenic list in the final hours of the Carter Administration.

CalTrout devotes the majority of its energies to the protection of rivers, streams and riparian habitats through administrative proceedings (SWRCB, FERC, etc.), litigation (CalTrout v. SWRCB [real party in interest, Los Angeles Dept. of Water and Power]), legislation, follow up with responsible agencies, and hands-on restoration (for example, Yellow Creek in Plumas County).

Central Sierra Watershed Coalition

The coalition purposes are to preserve the integrity of the watershed, advocate stewardship of the ecosystem and present alternate value analysis of sustainable low-impact recreation use. The coalition covers the geographic range from Merced to Mokelumne. Its goals are to assist local, state and federal agencies in developing alternative operations for the New Melones reservoir which would provide additional Stanislaus River flows for downstream and Delta fisheries, while restoring riparian vegetation and providing for white water recreation upstream. Coalition objectives include coordinating with Central Valley Project and state water political movements including water banking and "fair share" negotiations, restoring the main stem Stanislaus as a river of national significance and stopping the Clavey River Project.

Committee to Save the Mokelumne River

The committee has been a leading proponent for providing higher instream flows in the lower Mokelumne River downstream of existing water supply dams and diversions in order to restore the river's anadromous fisheries and mitigate pollution problems.

Desert Fishes Council

Organized in 1969, the Desert Fishes Council is an interdisciplinary group of more than 500 university research scientists and agency resource managers concerned with maintaining the biological integrity of desert aquatic ecosystems and their related floras and faunas. The council is involved with problems relating to the Colorado River and other desert streams.

Ducks Unlimited, Inc.

Ducks Unlimited works to protect and enhance North American wetland ecosystems with special emphasis on those habitats of greatest value to waterfowl; it has projects affecting nearly 500,000 acres in all 50 states.

Friends of the Garcia (FrOG)

The Garcia is a relatively short river in Mendocino County which has been affected by past timber harvest, ranching and aggregate extraction practices. As a result, the local fishery has been severely degraded. FrOG is working with a local resource conservation district to promote voluntary rehabilitation programs to restore the stream to its former productivity, and to promote public access while protecting the rights of private property owners.

Friends of the Los Angeles River

Friends of the Los Angeles River is working to restore riparian habitat and establish parkways along portions of the Los Angeles River.

Friends of the River

Organized in 1972 to save the Stanislaus River, Friends of the River expanded to become the largest statewide river conservation organization in the nation, with more than 10,000 members dedicated to the preservation and restoration of free-flowing rivers, streams and watersheds. Current conservation programs include encouraging Wild & Scenic designation of free-flowing rivers, stopping needless and destructive dam projects while developing environmentally

benign flood control, water supply and energy alternatives, and providing individual activists and watershed organizations the necessary training and skills to be effective river advocates.

Friends of the Santa Margarita River

Friends of the Santa Margarita River is working with a number of local, state and federal agencies to develop a cooperative management plan to preserve the outstanding scenic, wildlife and ecological values of the Santa Margarita River.

Keep the Sespe Wild Committee

Keep the Sespe Wild was formed to preserve, rehabilitate and protect one of the last relatively undeveloped watersheds in southern California. The Sespe has supported an anadromous fish population, and a major goal of Keep the Sespe Wild is the rehabilitation and preservation of that resource.

Klamath Forest Alliance

The alliance works to protect streamside riparian areas and to restrict logging in Klamath River watersheds and tributaries deemed critical for anadromous fisheries. The alliance is also organizing cooperative federal efforts to maintain optimum flows in the river for several endangered fish species.

Mattole Restoration Council

The Mattole Restoration Council is a community-based non-profit organization working to retain and restore natural systems within the Mattole River watershed to historic levels of health and productivity, especially in regard to forests, fisheries, soils, and native plant and animal communities. The council is made up of individual landowners and residents, as well as over a dozen smaller organizations in the watershed formed for specific purposes, such as restoration of a particular tributary, community education, land trusts and salmon restoration.

Mattole Watershed Alliance

The Mattole Watershed Alliance is a diverse group of individuals formed to address Mattole River watershed concerns through communication, education and cooperation. The alliance includes representation from all user groups, including ranchers, timber companies, large and small landowners, fishers and environmental restoration groups. One of their first projects was the

adoption of new, more protective, sport fishing regulations by the Fish and Game Commission.

The Nature Conservancy

The Nature Conservancy has established several preserves which are centered around or include riparian habitat within California. The Conservancy is a private, nonprofit conservation organization whose resources are entirely devoted to the acquisition and management of ecologically significant land.

Cosumnes River Preserve

The Cosumnes Preserve is located in Sacramento County on the eastern edge of the Sacramento-San Joaquin delta between Highway 99 and Interstate 5. The nearest town is Walnut Grove. The preserve is jointly owned by the conservancy, the Department of Fish and Game, the Bureau of Land Management, and Ducks Unlimited. The conservancy, in partnership with Ducks Unlimited, Inc., has launched an ambitious management and restoration project in the Preserve, one of the first of its kind between the two conservation organizations. The conservancy is restoring the riparian forests and Ducks Unlimited is restoring the wetlands.

Kern River Preserve

The Nature Conservancy started the Kern River Preserve in 1980, to protect plants, animals and natural communities which rely on this habitat for survival. The preserve is located along the South Fork, Kern River, 60 miles northeast of Bakersfield along State Highway 178 near Weldon. There are 1,133 acres of riparian forest currently in the Preserve. The preserve contains the largest continuous stand of riparian forest habitat in the state and 25 percent of the total Great Valley Cottonwood Riparian Forest found in California. Over 245 acres of the preserve are under restoration to re-establish a defined, native, historic ecosystem. The goal of this process is to replicate the structure, function, diversity and dynamism of that particular ecosystem.

The Sacramento River Project

The Sacramento River Project is perhaps the most geographically extensive undertaking by any conservation organization. The project encompasses 100 miles of river between Red Bluff and Colusa, and seeks to protect 50,000 acres of riparian forest and associated wetlands through acquisition of fee-title and conservation easements. The Sacramento River National Wildlife Refuge, managed by

the U.S. Fish & Wildlife Service, will be the main result of the project. The USFWS, the Wildlife Conservation Board (DFG) and the State Reclamation Board are acquiring riparian lands. The Nature Conservancy manages the forest on about 14,000 acres in scattered blocks of habitat. An equal acreage of flood-prone agricultural lands will be restored to riparian forest, with the goal of expanding existing forested blocks and connecting them with habitat corridors. Agricultural lease revenues will fund the habitat restoration. Restoration technologies are currently being developed in concert with local farmers and private land owners.

Putah Creek Council

The council is working with the U.S. Fish and Wildlife Service and the University of California, Davis, to develop a management plan and to restore riparian vegetation along Putah Creek. In addition, the council is working to increase stream flows from Monticello Dam.

Sacramento River Preservation Trust

Organized to stop destructive bank protection projects along the Sacramento River, the trust has been instrumental in focusing the efforts of state and federal agencies on the acquisition of riparian habitat along the river. The trust also supports the recovery of the river's many endangered species, including the winter-run chinook salmon.

San Joaquin River Committee

The San Joaquin River Committee is working to establish the San Joaquin River Parkway along the river, oppose unwise development in the flood plain and restore riparian habitat along the river.

San Joaquin River Parkway and Conservation Trust (SJRPECT)

The SJRPECT is a nonprofit public benefit corporation, organized for charitable and educational purposes. The trust's mission is to preserve and restore San Joaquin River lands of ecological, scenic or historic significance, to educate the public on the need for stewardship, to research issues affecting the river, and to promote educational and recreational uses of the river bottom consistent with protection of its environment.

Save the American River Association (SARA)

Save the American River Association is a citizen-volunteer group which advocates protection of the natural resources and recreational opportunities of the American River organized initially to

combat development of subdivisions along the American River Parkway, in recent years SARA has been involved in issues dealing with American River water supply allocation, including instream uses and flood control.

Sierra Club

The Sierra Club has been very active, primarily through the grass-roots efforts of its local chapters, in monitoring issues which affect rivers and streams. The club actively promotes conservation activities, and takes a particular interest in the environmental effects of such activities as gravel extraction on natural systems. The Sierra Club, founded in 1892 by John Muir, is by far the largest environmental organization in the state.

South Yuba River Citizens League (SYRCL)

SYRCL was originally formed in 1983 to oppose proposed hydroelectric projects on the South Yuba River. Since that time, while continuing its fight against hydro proposals, the organization has expanded its activities to include leasing land to hold for future park acquisition, monitoring the activities of the Yuba County Water Agency and promoting Wild and Scenic River designation for the river.

Tuolumne River Preservation Trust

The trust was formed in 1981, to protect the Tuolumne River from a proposed dam at Wards Ferry on the Clavey River. Through bipartisan efforts the river was designated Wild and Scenic by Congress, thus averting the development of the dam. Currently, the organization is interested in watershed resource management practices for the river and its tributaries. Efforts are focused on maintaining the Clavey River in its free-flowing state in the face of proposed development of a hydro-electric dam. The organization uses education, legal and political means to achieve its goals.

United Anglers of California

United Anglers of California is the state's largest fishery conservation organization working to restore and protect California's fisheries and their habitat. The organization's membership includes anglers, sport fishermen and affiliated fishing groups. It works with agencies and elected bodies to attain sound fishery management and funding to support such management. A tax-deductible subsidiary foundation, the Fishery Foundation of California, seeks funding for and conducts projects to enhance fishery production and restore fishery habitat. Projects range from restoration of several watersheds in the Eel River

drainage to creation of habitat for warm water fisheries in reservoirs. The foundation is pen rearing wild striped bass in the Delta and growing artificially produced white sea bass in pens along the Southern California Coast.

Urban Creeks Council

The council is a California nonprofit group formed to encourage the protection, preservation, and restoration of urban creeks. The council advocates land use planning to preserve creeks and decrease potential flood damage from creeks; promotes alternative flood control designs and alternative streambank stabilization techniques; provides assistance to grassroots neighborhood and community groups; conducts special projects; holds meetings, workshops and conferences to promote the aesthetic, ecological, and recreational value of urban creeks; and develops educational materials.

Regional Initiatives

The past decade has brought an increasing awareness at all levels of government and in the public of the signal importance of riparian systems to the overall health and welfare of the environment. Many significant regional initiatives have arisen, sometimes through the actions of government, but quite often at the instigation of private interest groups concerned with the continued well-being of areas which they have historically used for recreational and aesthetic refuge. These efforts are widely varied in goals, available resources, and ultimate potential for success.

Blue Bird Mine Riparian Rehabilitation and Enhancement Project

This \$32,300 initiative of the Shasta-Trinity National Forest will result in the restoration and enhancement of a closed mine which was not fully reclaimed. Activities will include an ecological inventory of the proposed project area, soil and ground cover enhancement measures, and enhancement of various anadromous fish and wildlife habitat characteristics of the area. Work will be accomplished through existing cooperative agreements between BLM, USFS and the multi-agency Trinity River Restoration Program. Portions of the work will be completed by local interest groups such as the Garden Club, Trinity County Mining Alliance, California Native Plant Society, Burnt Ranch 4-H Club and elementary school students.

Klamath River Fishery Restoration Program

This program is guided by the Klamath Fishery Task Force, which in 1991 consisted of representatives of the California commer-

cial salmon fishing industry, the in river sport fishing community, the California Department of Fish & Game, the Hoopa Valley Tribe, the Department of the Interior, the National Marine Fisheries Service, the Department of Agriculture, the Oregon Department of Fish & Wildlife, Del Norte, Siskiyou, Humboldt and Trinity counties, the Karuk Tribe and the Yurok Tribe. Projects are primarily funded through the Klamath Basin Fisheries Resources Restoration Act (P.L. 99-552), with matching nonfederal contributions. The principal objective is restoration of the once great fishery resources of the basin through habitat protection, management, and restoration, fish population protection and restoration, education and communication, and program administration.

Napa River Coordinated Resource Management and Planning Process (CRMP)

The Napa River CRMP is a joint effort of the San Francisco Bay Region (Region 11) Water Quality Control Board and the Napa County Resource Conservation District (NCRCD). The plan will recommend a series of cooperative land management strategies to maintain a healthy, sustainable watershed. Preliminary planning work is being funded by a grant from the State Water Resources Control Board.

Sacramento River Greenway

The Greenway Plan was initiated in 1990 by the State Lands Commission through a Memorandum of Understanding. A Cooperative Management Agreement (CMA) with the counties of Sacramento and Yolo and the City of Sacramento and the City of West Sacramento has been adopted (1993). A Greenway is proposed for a 31-mile corridor along both sides of the Sacramento River from the Sacramento/Sutter county line south through the cities of Sacramento and West Sacramento to Freeport. The goals of the plan are to accommodate public access and enhance riparian vegetation.

Salinas River Basin Water Resource Management Plan

The Salinas River Basin Water Resource Management Plan study is composed of a series of related elements designed to improve and protect water supplies for public and agricultural use in Monterey County. It includes development of a Basin Management Plan, which in turn includes development of a complete database and comprehensive plans for watershed, river channel, reservoir and groundwater management including saltwater intrusion issues. The program utilizes the expertise of both public and private sources, and is designed to foster public participation in the decision-making process.

Salinas River Coordinated Resource Management and Planning Process (CRMP)

In San Luis Obispo County local citizens, aided by staff from the county government and the Rivers and Trails Conservation Assistance Program of the National Park Service, have initiated a planning and problem-solving program for the upper Salinas River. Issues being addressed include trespass, access, water supply and water quality.

San Joaquin River Management Program Advisory Council (SJRAC)

The council is charged by the legislature (AB3603, Costa, Water Code §12260) to develop the San Joaquin River Management Program, as prescribed, to identify actions which can be taken to benefit legitimate uses of the San Joaquin River system. The program objectives shall be to develop compatible solutions to water supply, water quality, flood protection, fisheries, wildlife habitat and recreation needs. The study area covers the river from Friant Dam downstream through the Sough Delta Water Agency. DWR acts as staff to the council whose members represent federal, state and local agencies and nongovernmental organizations.

Trinity River Basin Fish and Wildlife Restoration Program

This project of the U.S. Fish and Wildlife Service will, when fully implemented, result in construction of anadromous fish habitat improvement measures in a 40-mile section of the Trinity River. Already completed pilot projects in this 10-year program (1986-1996), including gravel placement, pool dredging, and construction of side-channels and bank feathering sites, have provided information sufficient to prepare an overall plan for the approximately 40-miles of river from Lewiston Dam to the North Fork of the Trinity River. The overall project is funded for \$57 million.

Important Statutes Affecting California's Rivers

Federal

Watershed Protection and Flood Protection Act, 16 USCA § 1001, et seq.
 Rivers and Harbors Act of 1899, 33 USCA § 401, et seq.
 Clean Water Act, 33 USCA § 1251, et seq.
 Bridges Over Navigable Waters, 33 USCA § 491, et seq.
 River and Harbor Improvements Act, 33 USCA § 540, et seq.
 Flood Control Act, 33 USCA § 701, et seq.
 Wild and Scenic Rivers Act, 16 USCA § 1271, et seq.

Water Resources Development Act 33 USCA § 2201, et seq.
Endangered Species Act, 16 USCA § 1531, et seq.
Fishery Conservation Act, 16 USCA § 1801, et seq.
Soil and Water Resources Conservation Act, 16 USCA § 2001, et seq.
Small Hydroelectric Powerplant Projects Act, 16 USCA § 2701, et seq.
Fish and Wildlife Conservation Act, 16 USCA § 2901, et seq.
Toxic Substances Control Act, 15 USCA § 2601, et seq.
National Environmental Policy Act of 1969, 42 USCA § 4321, et seq.
Central Valley Project Improvement Act, 102 P.L. 575, 106 Stat. 4600

State

Porter-Cologne Water Quality Act, Water Code § 13000, et seq.
Hazardous Waste Control Law, Health and Safety Code § 25100, et seq.
Safe Drinking Water and Toxic Enforcement Act, Health and Safety Code § 25249.5, et seq.
California Environmental Quality Act, Public Resources Code § 21000, et seq.
California Endangered Species Act of 1973, Fish & Game Code § 2050, et seq.
Native Species Conservation and Enhancement Act of 1974, Fish & Game Code § 1750, et seq.
Wetlands Preservation Act of 1976, Pub. Res. Code § 5810, et seq.
Fish & Wildlife Habitat Enhancement Act of 1984, Fish & Game Code § 2600, et seq.
Davis-Dolwig Act of 1961, Water Code § 11900, et seq.
Land Conservation (Williamson) Act of 1965, Gov. Code § 51200, et seq.
Underground Storage Tank Act, Health & Safety Code § 25280, et seq.
Petroleum Underground Storage Tank Cleanup Act, Health & Safety Code § 25299.1, et seq.
Toxic Pits Cleanup Act, Health & Safety Code § 25208, et seq.
Hazardous Materials Release Response Plans & Inventory Act, Health & Safety Code § 25500, et seq.
Levee Maintenance Fund Act of 1973, Water Code § 12980, et seq.
Subdivision Map Act of 1975, Gov. Code § 66410
Coastal Act of 1976, Pub. Res. Code § 30000, et seq.
Salmon and Steelhead Spawning Areas, Pub. Res. Code § 6378
Surface Mining and Reclamation Act (SMARA), Pub. Res. Code § 2710, et seq.
McAteer-Petris Act, Gov. Code § 66600, et seq.
Fish and Game Code Provisions
 Fish and Wildlife Protection and Conservation, § 1600, et seq.
 Native Plant Protection, § 1900, et seq.
 Natural Communities Conservation Planning, § 2080
 Water Pollution, § 5650, et seq.
 Water releases for downstream fisheries, § 5937

Important Court Cases Affecting California's Rivers

Federal

Woodruff v. North Bloomfield Mining Co., 18 F. 753 (1884)
 Illinois Central Ry. v. Illinois, 146 U.S. 387 (1892)
 United States v. Utah, 283 U.S. 64 (1931)
 State of Alaska v. Ahtna, Inc., 891 F.2d 1401 (9th Cir. 1989)

State

People v. Gold Run Ditch and Mining Co., 66 Cal. 138 (1884)
 Wright v. Seymour, 69 Cal. 122 (1886)
 People v. Truckee Lumber, 116 Cal. 397 (1897)
 People v. Russ, 132 Cal. 102 (1901)
 Forestier v. Johnson, 164 Cal. 24 (1912)
 People v. California Fish, 166 Cal. 576 (1913)
 Bohn v. Albertson, 107 Cal.App.2d 738 (1951)
 Marks v. Whitney, 6 Cal.3d 251 (1970)
 People ex rel. Baker v. Mack, 19 Cal.App.3d 1040 (1971)
 Hitchings v. Del Rio Woods, 55 Cal.App.3d 560 (1976)
 People v. Sweetser, 72 Cal.App.3d 278 (1977)
 People ex rel. Younger v. El Dorado Co., 96 Cal.App.3d 403 (1979)
 State v. Superior Court (Lyon), 29 Cal.3d 210 (1981)
 State v. Superior Court (Fogerty), 29 Cal.3d 240 (1981)
 National Audubon Society v. Superior Court, 33 Cal.3d 419 (1983)
 Kern River Public Access v. Bakersfield, 170 Cal.App.3d 1205 (1985)
 CalTrout v. State Water Resources Control Board, 207 Cal.App.3d 585 (1989)
 CalTrout v. Superior Court, 218 Cal.App.3d 187 (1990)
 Bess v. County of Humboldt, 3 Cal.App.4th 1544 (1992)

References

Chapter One

Beck, Warren A. and Ynez Haase. 1974. Historical Atlas of California. University of Oklahoma Press. Norman, Oklahoma.

California Department of Fish and Game. 1991a. Sport fishing for anadromous nonsalmonid fishes. Draft satellite environmental document. Sacramento.

California Department of Fish and Game. 1991b. Sport fishing for anadromous salmonid fishes. Draft satellite environmental document. Sacramento.

California Department of Parks and Recreation, State Park System General Plan, Vol. 8, 1984. Sacramento.

California Department of Water Resources. 1992a. Dams within jurisdiction of the State of California. Division of Safety. Dams Bulletin 17-92.

California Department of Water Resources. 1992b. Data base. Division of Safety of Dams. Sacramento.

California Water Atlas. 1979. California Governor's Office of Planning and Research, in cooperation with Department of Water Resources. Sacramento. 118p.

Dasman, Raymond F. 1965. The destruction of California. Collier Books, New York. 223p.

Downie, Scott. 1991. North coast salmon and steelhead and their habitat (1). Pp. 46-51 in Allan Lufkin, ed., California's salmon and steelhead. University of California Press, Berkeley.

Kroeber, A.L. 1925. Handbook of the Indians of California, Bureau of American Ethnology of the Smithsonian Institution. Bulletin No. 78. (Dover Publications Reprint, 1976)

- Kroeber, A.L. 1935. Culture element distributions in S. Klimek. University of California American Archaeology and Ethnology 37. Berkeley.
- Loomis, John and Chris Unkel. 1989. The economic contribution of wildlife viewers. Outdoor California. Department of Fish and Game. 84p.
- Lufkin, Allan. 1991. Historical highlights. in Allan Lufkin, ed., California's Salmon and Steelhead. Pp. 6-36. University of California Press, Berkeley.
- McEvoy, Arthur F. 1986. The fisherman's problem: ecology and law in the California fisheries 1850-1980. Cambridge University Press, Cambridge, GB. 368p.
- National Parks Service. 1990. Skykomish River: a preliminary scenic assessment procedure. Washington State Parks and Recreation Commission.
- Reynolds, Forrest L., Robert Reavis, and Jim Schuler. 1990. Central Valley salmon and steelhead restoration and enhancement plan. California Department of Fish and Game. Sacramento. 115p.
- Roberts, Ruth Kellett. 1932. Conservation as formerly practiced by the Indians in the Klamath River Region. California Fish and Game 18(4): 283-290.
- Schulz, Peter D. and Dwight D. Simons. 1973. Fish species in a prehistoric central California Indian midden. California Fish and Game 59(2): 107-113.
- Sport Fishing Institute. 1989. The economic impact of sport fishing in the state of California. Washington., D.C.
- Thompson, Kenneth. 1961. Riparian forests of the Sacramento Valley. Annals of the Association American Geographers 51(3):294-315.
- Tripp, David K. 1984. Warm Springs Dam-Lake Sonoma ethnobotanical preserve: an attempt to mitigate for a cultural loss. Pp. 780-782 in Warner, Richard E. and Kathleen Hendrix, eds. California Riparian Systems. University of California Press, Berkeley.
- Yeend, W. 1974. Gold-bearing gravel of the ancestral Yuba River, Sierra Nevada, California. U.S. Geological Survey Prof. Paper 772.

Chapter Two

Armour, C.L., D.A. Duff and W. Elmore. 1991. The effects of livestock grazing on riparian and stream ecosystems. *Fisheries*. 16:7-11.

Beschta, Robert L., Robert E. Philby, George W. Brown, L. Blair Holtby and Terry D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. Pp. 191-232 in Ernest O. Salo and Terrance W. Cundy, eds., *Streamside Management: Forestry and Fishery Interactions*. Institute of Forest Resources Contribution No. 57. University of Washington, Seattle.

California Advisory Committee on Salmon and Steelhead Trout. 1988. *Restoring the balance*. 1988 Annual Report to California State Legislature and Department of Fish and Game. 84p.

California Department of Food and Agriculture. 1992. *California agriculture statistical review 1991*. Sacramento.

California Department of Forestry and Fire Protection. 1988. *California's forests and rangelands: growing conflict over changing uses*. Forest and Rangeland Resources Assessment Program (FRRAP). Sacramento. 348p.

California State Lands Commission. 1986. *Sacramento River marina carrying capacity study*. Sacramento.

California State Water Resources Control Board. 1991a. *Clean water strategy: guidance for water body based decision making*. Sacramento.

California State Water Resources Control Board. 1991b. *Water quality assessment summary report, water quality concerns. preliminary report*. Sacramento.

Charbonneau, Robert B. and G. Mathias Kondolf. 1991. Land use conversion as a source of contaminants. Pp. 41-56 in *Proceedings of the Conference Protecting Drinking Water at Its Source*, April, 1991. University of California Water Resources Center Report 76.

Elmore, Wayne. 1989. Rangeland and riparian ecosystems. Pp. 93-95 in Dana L. Abell, tech. coord., *Proceedings of the California Riparian Systems Conference: Protection Management, and Restoration for the 1990's*, Sept. 22-24, 1988, Davis, California. USDA Forestry Service Gen. Tech. Rpt. PSW-110.

- Everest, Fred H., Robert L Beschta, J. Charles Scrivner, K.V. Koski, James R. Sedell and C. Jeff Cederholm. 1987. Fine sediment and salmonid production: a paradox. Pp. 98-134 *in* Ernest O. Salo and Terrance W. Cundy, eds., *Streamside Management: Forestry and Fishery Interactions*. Institute of Forest Resources Contribution No. 57. University of Washington, Seattle.
- Holland, Robert F. and Faber, Phyllis M. 1988. *Common riparian plants of California*. Pickleweed Press, Mill Valley, California. 139p.
- Jenkins, Olaf. 1938. Geomorphic map of California. Accompanying map to Norman E.A. Hinds. 1952. *Evolution of the California Landscape*. California Division of Mines Bulletin 158.
- Kondolf, G.M. and W.V.G. Matthews. 1990. Assessment of potential impacts of Monterey Peninsula Water Supply Project Alternatives on downstream channel geometry of the Carmel River. Report to the Monterey Peninsula Water Management District.
- Kondolf, G.M. and M.L. Swanson. 1993. Channel adjustments to reservoir construction and gravel extraction along Stony Creek, California. *Environmental Geology and Water Science*. (In press).
- Moyle, Peter B. 1976. *Inland Fishes of California*. University of California Press, Berkeley. 405p.
- National Research Council. 1992. *Restoration of aquatic ecosystems: science, technology, and public policy*. National Academy Press, Washington, D.C. 485p.
- Reid, L.M. and T. Dunne. 1984. Sediment production from forest road surfaces. *Water Resources Research* 20:1753-1761.
- Roberts, Warren G., J. Greg Howe and Jack Major. 1977. A Survey of riparian forest flora and fauna in California. Pp. 3-19 *in* Anne Sands ed., *Riparian Forests in California: Their Ecology and Conservation*. Institute of Ecology Publication No. 15. University of California, Davis.
- Upper Sacramento River Fisheries and Riparian Habitat Advisory Council. 1989. Upper Sacramento River fisheries and riparian habitat management plan ("SB1086" Plan). Report to California Legislature. Resources Agency, Sacramento. 158p.

Chapter Three

California Department of Fish and Game. 1992a. 1991 Annual Report on the status of California state listed threatened and endangered plants and animals. Sacramento. 191p.

Hedgpeth, Joel W. 1991. The passing of the salmon. Pp.52-60 in Allan Lufkin, ed., California's Salmon and Steelhead. University of California Press, Berkeley.

Katibah, Edwin F. 1984. A brief history of riparian forests in the Central Valley of California. Pp. 23-29 in Richard E. Warner and Kathleen Hendrix, eds., California Riparian Systems. University of California Press, Berkeley.

Laymon, Stephen A. and Mary D. Halterman. 1989. A proposed habitat management plan for Yellow-billed Cuckoos in California. Pp. 272-277 in Dana L. Abell, tech. coord., Proceedings of the California Riparian Systems Conference: Protection Management, and Restoration for the 1990's, Sept. 22-24, 1988, Davis, California. USDA Forestry Service Gen. Tech. Rpt. PSW-110.

Minckley, W.L. and David E. Brown. 1982. Wetlands. Part 6 of D.A. Brown, ed., Biotic Communities of the Southwest—United States and Mexico. Special Issue, Desert Plants 4(1-4):1-342.

Minshall, G. Wayne, Sherman E. Jensen, and William S. Platts. 1989. The ecology of stream and riparian habitats of the Great Basin Region: a community profile. U.S. Fish and Wildlife Service Biological Report 85(7.24). 142p.

Moyle, Peter B. 1976. Inland Fishes of California. University of California Press, Berkeley. 405p.

Moyle, Peter B., Jack E. Williams, and Eric. D. Wikramanayake. 1989. Fish species of special concern of California. California Department of Fish and Game, Sacramento. 222p.

Nehlsen, Willa, Jack E. Williams, and James A Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho and Washington. Fisheries (Bethesda) 16:4-21.

Ohmart, Robert D., Wayne O. Deason, and Constance Burke. 1977. A riparian case history: the Colorado River. Pp. 35-47 in Roy R. Johnson and D.A. Jones, tech. coords., Importance, Preservation, and Management of Riparian Habitat: a Symposium. USDA Forest Service Gen. Tech. Report RM-43.

Ray, Dan, Wayne Woodroof, and R. Chad Roberts. 1984. Management of riparian vegetation in the north coast region of California's Coastal Zone. Pp. 660-672 in Richard E. Warner and Kathleen Hendrix, eds., *California Riparian Systems*. University of California Press, Berkeley.

Reynolds, Forrest L., Robert Reavis and Jim Schuler. 1990. Central Valley salmon and steelhead restoration and enhancement plan. California Department of Fish and Game. Sacramento. 115p.

Upper Sacramento River Fisheries and Riparian Habitat Advisory Council. 1989. Upper Sacramento River fisheries and riparian habitat management plan ("SB1086" Plan). Report to California Legislature. Resources Agency, Sacramento. 158p.

Chapter Four

Brinson, M.M., B.L. Swift, R.C. Plantico and J.S. Barclay. 1981. Riparian ecosystems: their ecology and status. U.S. Fish and Wildlife Service Biol. Serv. Prog. FWS/OBS-81/17. Washington D.C. 151p.

Brode, John M. and R. Bruce Bury. 1984. The importance of riparian systems to amphibians and reptiles. Pp. 30-36 in Richard E. Warner and Kathleen Hendrix, eds., *California Riparian Systems*. University of California Press, Berkeley.

California Department of Fish and Game. 1992. 1991 Annual report on the status of California state listed threatened and endangered plants and animals. Sacramento. 191p.

Cowardin, Lewis M., Virginia Carter, Francis C. Golet and Edward T. LaRoe. 1979. Classification of wetlands and deep water habitats of the United States. U.S. Fish and Wildlife Service. FWS/OBS-79/31. Washington, D.C. 103p.

Cummins, Kenneth W. 1974. Structure and function of stream ecosystems. *Bioscience* 24(11):631-641.

DeBano, Leonard F. and Larry J. Schmidt. 1989. Improving southwestern riparian areas through watershed management. USDA Forest Serv. Gen. Tech. Rpt. RM-182. 33p.

Eng, Larry. 1984. Rare, threatened, and endangered invertebrates in California riparian systems. Pp. 915-918 in Richard E. Warner and Kathleen Hendrix, eds., *California Riparian Systems*. University of California Press, Berkeley.

Faber, Phyllis M., Ed Keller, Anne Sands and Barbara Massey. 1989. The ecology of riparian habitats of the Southern California coastal region: a community profile. U.S. Fish and Wildlife Service Biological Report 85(7.27). 152p.

Fjerdingstad, E. 1975. Bacteria and fungi. Pp. 129-140 *in* H.A. Whitton, ed., *River Ecology*. University of California Press, Berkeley.

Fry, Donald H., Jr. 1979. *Anadromous fishes of California*. California Department of Fish and Game. 112p.

Goldman, Charles R. and Alexander Horne. 1983. *Limnology*. McGraw-Hill, New York. 464p.

Gregory, Stanley, Frederick J. Swanson, W. Arthur McKee and Kenneth Cummins. 1991. An ecosystem perspective of riparian zones. *Bioscience* 41(8):540-551.

Hawkes, H.A. 1975. River zonation and classification. Pp. 312-374 *in* H.A. Whitton, ed., *River ecology*. University of California Press, Berkeley.

Herbold, Bruce and Peter B. Moyle. 1989. The ecology of the Sacramento-San Joaquin Delta: a community profile. U.S. Fish and Wildlife Service Biol. Report. 85(7.22) 106p.

Hupp, Cliff and W.R. Osterkamp. 1985. Bottomland vegetation distribution along Passage Creek, Virginia, in relation to fluvial landforms. *Ecology* 66(3): 670-681.

Hynes, H.B.N. 1970. *The ecology of running waters*. University of Toronto Press, Toronto. 555p.

Jensen, Deborah B., Margaret Torn and John Harte. 1990. *In our own hands: a strategy for conserving biological diversity in California*. California Policy Seminar Research Report, University of California, Berkeley. 184p.

Jensen, Sherman E. and W.S. Platts. 1989. Restoration of degraded riverine/riparian habitats in the Great Basin and Snake River regions. Pp. 367-404 *in* Jon A. Kusler and Mary E. Kentula, eds., *Wetland Creation and Restoration: The Status of the Science*. Island Press, Washington, D.C.

Keller, E.A. 1977. The fluvial system: selected observations. Pp. 39-46 *in* Anne Sands ed., *Riparian Forests in California: Their Ecology and Conservation*. Institute of Ecology Publication No. 15. University of California, Davis.

- Kelsey, H.M., M.A. Madej, J. Pitlick, M. Coghlin, D. Best, R. Belding and P. Stroud. 1981. Sediment sources and sediment transport in the Redwood Creek basin: a progress report. Redwood National Park, Arcata, California. 114p.
- Mayer, Kenneth E. and William F. Laudenslayer, Jr., eds. 1988. A guide to wildlife habitats of California. California Department of Forestry and Fire Protection. Sacramento. 166p.
- McGinniss, Samuel M. 1984. Freshwater fishes of California. California Natural History Guide 49. University of California Press, Berkeley. 316p.
- Miller, A.H. 1951. An analysis of the distribution of birds of California. Univ. Calif. Publ. Zool. 50:531-643.
- Mooney, H. A., S. P. Hamburg and J.A. Drake. 1986. The invasion of Plants and animals into California. Pp. 250-272 in Harold A. Mooney and James A. Drake, eds., Ecology of Biological Invasions of North America and Hawaii. Springer-Verlag, New York.
- Moyle, Peter B. 1986. Fish introductions into North America: patterns and ecological impact. in Harold A. Mooney and James A. Drake, eds., Ecology of Biological Invasions of North America and Hawaii. Springer-Verlag, New York.
- Moyle, Peter B., Jack E. Williams and Eric. D. Wikramanayake. 1989. Fish species of special concern of California. California Department of Fish and Game, Sacramento. 222p.
- Moyle, Peter B. and Jack E. Williams. 1990. Biodiversity loss in the temperate zone: decline of the native fish fauna of California. Conservation Biol. 4:475-84.
- Moyle, Peter B. and Robert A. Leidy. 1992. Loss of biodiversity in aquatic ecosystems: evidence from fish faunas. Pp.127-169 in Peggy L. Fiedler and Subodh K. Jain eds., Conservation Biology: the Theory and Practice of Nature Conservation, Preservation, and Management. Chapman and Hall, New York.
- National Research Council. 1992. Restoration of aquatic ecosystems: science, technology, and public policy. National Academy Press, Washington, D.C. 485p.
- Nehlsen, Willa, Jack E. Williams and James A Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho and Washington. Fisheries (Bethesda) 16:4-21.

Pacific Fishery Management Council. 1992. Review of 1991 oceansalmon fisheries. Pacific Fishery Management Council. Portland.

Reid, George C. and Richard D. Wood. 1976. Ecology of inland waters. (2nd ed.) D. Van Nostrand Co., New York. 485p.

Roberts, Warren G., J. Greg Howe and Jack Major. 1977. A Survey of riparian forest flora and fauna in California. Pp. 3-19 in Anne Sands ed., Riparian Forests in California: Their Ecology and Conservation. Institute of Ecology Publication No. 15. University of California, Davis.

Scott, Lauren and Sandra K. Marquiss. 1984. An historical overview of the Sacramento River. Pp. 51-57 in Richard E. Warner and Kathleen Hendrix, eds., California Riparian Systems. University of California Press, Berkeley.

Smith, Gerald and Ralph F. Stearly. 1989. The classification and scientific names of rainbow and cutthroat trouts. Fisheries 14(1):4-10.

Trapp, Gene R. Gail L. Linck and Edward D. Whisler. 1984. The status of ecological research on the mammalian fauna of California's Central Valley riparian communities. Pp. 942-949 in Richard E. Warner and Kathleen Hendrix, eds., California Riparian Systems. University of California Press, Berkeley.

U.S. Congress Office of Technology Assessment. 1987. Technologies to maintain biological diversity. OTA-F-330. U.S. Government Printing Office. Washington, D.C.

Zeiner, David C., William F. Laudenslayer, Jr. and Kenneth E. Mayer, eds. 1988. California's wildlife. Vol. I. amphibians and reptiles. California Statewide Wildlife Habitat Relationships System, California Department of Fish and Game, Sacramento. 272p.

